CHEMISTRY

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* Paper from the International Conference on the Peaceful Uses of Atomic Energy.

Editorial:
Earth is a Cosmic Puzzle
Inside Front Cover

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Earth Is a Cosmic Puzzle

➤ THE STRUCTURE of our earth is a puzzle which piques the curiosity of man's mind. Digging only a little way down through the sand, clay and organic humus which make up the soil we strike the "living" rock which the Greeks called the "bones of Mother Earth". But seismology reveals, by the differences between earthquake waves recorded after passing through the central part of the earth and those travelling along a relatively shallow path through earth's crust, that the seemingly solid rock ends at a definite depth. Below that line there is a well-defined core of greater density.

Measurements of earth's mass and volume lead to the conclusion that this solid core has about the density of iron, and our planet is often described as a ball of iron with a coating of slag sticking to the outside. Blast furnace slag is largely a silicate of calcium and aluminum, just like many rocks, and the comparison is apt. Scientists interested in the possible early states of the earth wonder how this slag was formed.

Two theories of earth's origin have always contended in men's minds. Some people, reasoning from analogy with volcanoes, have envisioned the planets cooling gradually from a molten state. They have projected this imaginary history back to an eruption of the sun which drew out the string of planets as blobs of flaming gas. The other theory finds the planets constantly growing by sweeping up cosmic dust.

The only record we have to help us decide between these theories are to be found in the rocks themselves. But until very recently we have known almost as little about rock formation as about cosmic processes. It is now possible not only to make synthetic rocks and minerals in the laboratory, but to map out the regions of pressure and temperature where definite compounds can exist, and to caluculate the energy requirements for forming them. Some day this puzzle may be solved.

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➤ GRANITE *forms large masses of crystalline rock which cracks in characteristic patterns. Origin of this hard, durable stone is now being reviewed as a result of new knowledge of the formation of crystals.*

Eternal Granite

By HELEN M. DAVIS

➤ GRANITE, symbol of eternal changelessness, is the latest subject of sceptical inquiry. Is this hard, crystalline rock, characteristically spotted with distinct grains of quartz, feldspar and mica, really the earliest kind of rock in the world? Or has it resulted from chemical reworking of earlier deposits long since immersed in the strangely fluid rock mantle that forms the crust of our mysterious globe?

Boiling lavas, belching flames, shuddering earthquakes and mighty cataclysms of nature out-

line the geologists' reconstruction of the past. Those who trace earth's history in the record of the rocks find evidence of enormous forces at work.

Early students of these records had no time scale against which to measure the effects of mountain building and erosion. They knew the damage which volcanoes and earthquakes can do in limited areas, and ascribed all changes in earth's crust to similar violent shifts in rock strata. It has taken a long time to get the prototype of hell-fire out of geology.

Age of the Earth

Interpretation of fossil remains of plant and animal life in the light of evolution gradually forced recognition of the fact that the earth is very much older than the forms of life which inhabit it today. Relative ages were worked out for the alternating layers of different sorts of rocks. Pressures which raise mountain chains and forces of wind and water that wear them down were recognized as quiet but insistent factors constantly in operation over long periods of time.

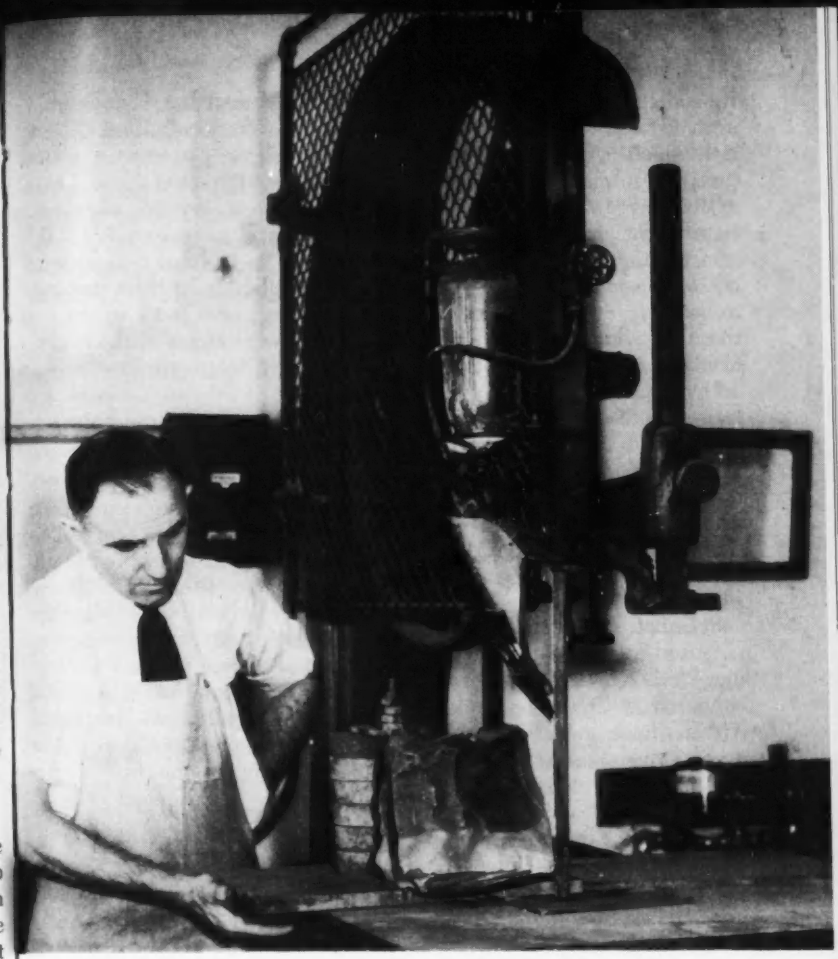
Duration of the geologic ages came to be reckoned in millions of years, to give time for the accumulation of sediments whose history is fairly easy to read in strata of the rocks. But the granites remained, early, lifeless, crystalline and hard. They are pointed out as samples of the original surface of the earth. They are supposed to have crystallized out of the cooling magma as a once-liquid earth solidified. Their crystals formed, apparently, just as a scum of salt crystals forms on the surface of an evaporating salt solution.

Nobody questioned the formation of granite until recently, because there was no way to duplicate the chemical conditions supposed to have been present in the primordial earth.

Recently equipment has been built in which a small amount of rock-matter can be treated with conditions of great heat and pressure, such as early geologists imagined must be found deep in the interior of the earth. With this equipment present day scientists can create many of the named minerals, recognized by their hardness, color and crystalline habit.

Minerals Synthesized

Mica and quartz, two of the kinds of crystals which make up granite, have been synthesized in the laboratory. Many trials were made by many experimenters, but genuine crystals having the same properties as those found in nature were achieved. Strong practical needs added an urge for achieving the synthetic mineral in each of these cases. Electronic work was hampered by scarcity of good crystals of mica, for use



▸ ROCK-SLICING *machine cuts thin sections of even the hardest rocks, showing alternating crystals of quartz, feldspar and mica in granite, for study under the microscope.*

as insulating material, and of quartz needed for its piezo-electric properties. Quartz is an oxide of silicon. Mica belongs to one of the numerous families of silicate rocks.

Feldspar, the third partner in granite, is also a complex silicate.

It occurs in chunky crystals, while mica is famed for the thin sheets into which it can be split. While the pure forms of all three granite-forming minerals are white to transparent in color, they are sometimes modified by both chemical and physical means into a variety of shades ranging through yellows, reds and browns to black. All these colors are prized by those who quarry ornamental stones. The high polish which granite takes, and its resistance to weathering, make it a favorite material for outdoor uses ranging from public buildings to tombstones.

Silicates Studied

Scientists studying granite have not tried to duplicate any particular kind of feldspar, but to study exhaustively the compounds which silicon makes with aluminum, with sodium and potassium, and with other elements commonly found in rocks. Since these may include iron, lithium, rubidium, cesium, copper, gallium, lead, silver, thalium, titanium, zirconium, nickel, vanadium, scandium, chromium, strontium and boron, researchers first tried to limit their studies to problems which would shed light on some general problems in geology.

While these researches were going on, the work of other scientists provided new side-lights on granite's origin.

A great deal has been learned about how crystals form. Photographs show patterns in which X-rays are diffracted by the layers of atoms in crystal structures. Physicists experienced in the study of such diffraction patterns can calculate from them not only the arrangement but also the size of individual atoms in the crystal. They learn that many crystals are imperfect, and have found the causes of some of these imperfections.

Some irregularities occur because an atom of one element has been replaced by one of a different element. Since atoms of different elements are of different sizes, or at least differ in the amount of space they take up, such a replacement puts a strain on the structure of the crystal where it happens. Introduction of many new atoms which are larger than the original ones may shatter the crystal. Replacement of large atoms by smaller ones may make the crystal collapse.

Changes by Transmutation

In addition to the well-known effects caused by growth of new crystals intruding into older rock forms, recent study of the effects of radioactive ores underground have shown that in some cases the radiations transmute elements into new elements in the minerals.

Since granite is a highly crystalline material, all these new

facts about what can happen to crystals are being applied to such rock.

Two schools of thought on the origin of granite are represented by a discussion in progress in the *American Journal of Science, (January, 1955)* published at Yale University, New Haven, Conn. Prof. Matt Walton of Yale's Department of Geology holds to the idea that the crystals form from a fluid magma. This magma, he believes, can move about underground as the result of various kinds of stresses. At one time it can fill a gap left when rock masses already present shift their positions. At another time the migrating fluid substance can push other formations out of its way. In either case, crystalization of the fluid then takes place. Granitic rock formations are the result.

Replacement in Solid

Arguing for another source of granite is Dr. R. Perrin of Paris, *(American Journal of Science, January, 1956)* who admits being an "extreme transformist." He believes that "it is scientifically certain that a large number of granites have been formed by replacement in the solid and very unlikely that other granites may have originated from direct crystallization of magmas."

However, the points of view set forth in this controversy are not irreconcilable. They illustrate steps in understanding the evidence at hand. They will lead to further understanding of complex laws operating on a grand scale.

Among the research groups interested in the problem of granite origin is the Geophysical Laboratory of the Carnegie Institution, located in Washington, D. C. With equipment designed by Dr. George W. Morey of that institution, pressures can be obtained comparable to those acting on rocks deep in the surface of the earth. Beginning in about 1940, this technique was used in the study of silicate solutions which the Carnegie scientists had been carrying on for some five years previously.

Systematic mapping of the crystalline forms of compounds made up of silica and the alkaline silicates in varying proportions was undertaken. An unexpected result of such studies showed that quartz which solidified from a hot melt can be distinguished from quartz which has crystallized at a low temperature. Acting on this clue, Drs. O. Frank Tuttle and M. L. Keith of the Geophysical Laboratory tested a number of samples of granite from different localities. This settled one problem. They found the quartz in their granites to be of high temperature origin.

Other studies of the possible combinations of sodium and po-

tassium with silicon and aluminum, including varying proportions of oxygen and hydrogen, were carried on in subsequent years, at the Carnegie Institution, largely by Dr. Norman L. Bowen and Dr. O. Frank Tuttle. These provided a solid background for later studies of granite, as well as contributing toward the synthesis of mica by Drs. Bowen and Tuttle in 1948. *(See* CHEMISTRY, *Feb., 1948).*

High Pressures

High temperatures and enormous pressures have been shown experimentally to result in the kinds of mineral crystals which geologists find in rocks. Design and building of machines which can be used to create such pressures in the laboratory was advanced by Dr. Percy W. Bridgman of Harvard University, and apparatus of the type developed by Dr. Bridgman has recently been modified by scientists at the research laboratories of General Electric Co. to add the dimension of continued heating at high temperatures. With such apparatus the synthesis of diamonds and garnets has been achieved. *(See* CHEMISTRY, *March, 1955)*

Granites do not require the high temperatures at which these gem crystals form. The problem they pose for geologists and chemists is in the separation of their particular elements from compounds of other common elements, such as iron and magnesium.

"We seem to find general agreement", says Dr. Walton, in the *American Journal of Science,* "that granite-forming elements *do* tend to separate and become localized to form granite under certain geological conditions. We all agree on some general thermodynamic reason *why* they should tend to separate from the ferromagnesian elements. We are groping for the answer to HOW.

"Answers to this question may come from three lines of attack", Dr. Walton continues. "One is experimental. Here we have a considerable body of information on the stability relations of silicates in dry melts but very inadequate data on systems containing high vapor pressures of water and other volatiles."

Limiting Conditions Unknown

Dr. Walton goes on to state that "as yet no one can honestly define on the basis of experimentally established fact the geologically realizable limiting conditions for the formation of granite magma or granitizing solutions, nor can anybody predict what the final texture of a granite should look like if it has crystallized from a magma under plutonic conditions."

"A second line of attack", Dr. Walton continues, "is by theoreti-

cal thermodynamics and crystal chemistry. The complexity of silicates and silicate systems and the limited amount of fundamental data restrict the effectiveness of this approach. As is so frequently the case with thermodynamic problems, it is sometimes possible to predict the direction that geologically interesting reactions should proceed under equilibrium conditions, but the calculation of reaction rates and prediction of the paths taken by reactions from reactants to products are generally beyond the reach of theoretical determination. Unfortunately, if we are to answer the question, 'how', the paths and rates are precisely the things we need. We can theorize that a certain ion is more stable here than there, but how it gets from here to there, or if it gets from here to there at all within a reasonable interval of time generally defies theoretical analysis in the present state of our knowledge.

"Finally we have the classical geological approach of deduction from the appearance of things in nature. The elusive thing about the granite problem and plutonic geology in general is that we never can observe actual processes in action. We must guess at processes from the appearance of things long after the processes have ceased to operate."

But the French geologist, Dr. Perrin, draws on experience in metallurgy to insist that "once a current of ions is started by chemical reactions, it can proceed through on crystals or along the boundaries of crystals that have become passive, to achieve the decrease of the total free energy between minerals, the distance between which increases continuously."

No great prizes await the solving of the mystery of granite, not even the satisfaction of a commercial need, for there seems to be plenty of this durable stone. But the problems of silicate chemistry are intricate and baffling. Silica is as common as the sand under our feet, and until recently little attention was paid to it.

With the discovery of "silicones", the compounds analogous in the inorganic field to the organic compounds of carbon, new interest has awakened in the element silicon. Its rock-forming compounds also offer problems of almost endless opportunity to chemists interested in tracing the atomic architecture of our stony globe.

Lemonade powder rich in natural flavor has been developed by the U. S. Department of Agriculture.

Helium, the lightweight inert gas produced only by the Bureau of Mines, is finding increased use in the field of metallurgy.

More Uranium Production Will Endanger World

Uranium and the Future

➤ WORLD PRODUCTION of uranium is about to reach the saturation point when all that can be used safely will be produced, in the opinion of Prof. George W. Bain of Amherst College's geology department.

The recent opening of the Pronto Mine in the Blind River District in Ontario, Canada, marks the effective end of uranium hunting, he suggested.

Within a year or two the Blind River area, in conjunction with existing producers, will be furnishing as much uranium annually as can be safely used in the entire world, Prof. Bain said. It has been estimated that the surface of the earth can dissipate radioactive byproducts from the fission of a maximum of 15,000 tons of uranium annually.

Unless we discover a more efficient method of fission in using atomic power, 15,000 tons is the maximum that can be safely used, he said. No greatly improved or radically new method is now in sight.

The series of mines in the Blind River District, of which Pronto is the first, will produce enough uranium shortly to reach the safe limit, Prof. Bain estimates. Although the potential production figures are an official Atomic Energy Commission secret, they can be calculated.

The prospectus offering Blind River stock estimates that uranium metal yield from the area will be between two and three pounds of metal to each ton of ore. The size of the ore deposit is known. It is an old river bed, gravel averaging for most of its length, 40 feet deep, 10,000 feet wide, and 22 miles long. The expected annual yield of the mines that are now being developed in the area is also known.

Calculating the annual yield, the Blind River area mines, operating at existing planned mill capacity, can supply uranium for the next 400 years or the entire world requirements for 120 years.

Prof. Bain pointed out two factors resulting from this conclusion:

1. The world will have to find a way of policing uranium consumption. Many nations, including Australia and South Africa, which are uranium producers and are short of mechanical power, are very eager to use the power to be derived from uranium. These countries as well as the

nations of Western Europe, Soviet Russia, the United States and Canada may try to use as much atomic power as they can.

Excessive fission will endanger human life, scientists feel. Prof. Bain's opinion is that the problem of fission control is one for the United Nations, probably the most important problem the UN has ever faced. Furthermore, the equatorial septum in the earth's atmospheric and oceanic circulation makes Northern and Southern Hemisphere problems independent of each other.

2. Economically feasible uranium prospecting is at an end. Prof. Bain who has intimate first hand knowledge of most of the world's possible uranium sources feels that no one will be able to find a deposit to match the wealth of the Blind River District. Eventually, he feels no source will be able to compete with Blind River. The Canadian government's price of $12.60 per pound of metal will drop for all uranium deposits not blocked out by March 31 of next year, giving the Blind River area a tremendous financial advantage over potential future competitors.

The Pronto Mine, opened officially this fall, will produce about two tons of uranium metal a day or about 700 tons a year. It may be for the moment the biggest single producer in the world. Next fall the nearby Algom mine is scheduled to start operating with a production of roughly 3,600 tons of metal a year. Another mine in the area will start production early in 1957.

Russian Bomb Fallout

➤ RUSSIAN radioactivity fell with the snow that blanketed the American city of Helena, Mont., on Nov. 26. The snow contained radioactivity decay definitely characteristic of a recent nuclear explosion, Norman J. Holter, research director and vice-president of the Holter Research Foundation, declared.

The intensity of the radioactive fallout was not enough to be dangerous to the citizens of Helena and was "well within safe limits."

The Holter Research Foundation in Helena is one of the few independent laboratories in the nation that spot check radioactivity.

Mr. Holter stated that the radioactivity is presumed to be of Russian origin since there had been no indication of recent American tests.

The report of fallout in the radioactive-laden Montana snow was delayed until the Holter scientists could obtain statistically adequate decay data. Reports of radioactivity intensity alone, Mr. Holter explained, are insufficient to confirm any nuclear explosion.

The U.S. Atomic Energy Commission announced on Nov. 23

that the Russians had detonated their largest nuclear device thus far.

Nation's Bomb Tests Known

➤ IT IS IMPOSSIBLE to set off an A-bomb or an H-bomb these days without the rest of the world knowing about it.

The day of unannounced atomic detonations is at an end. Monitoring stations, both governmental and independent, detect nuclear explosions, pinpoint the location of the test site, time of detonation and size, type and make-up of the device.

Much of the detecting is deliberate, but some detection is inadvertently made when unusual amounts of radioactivity unleashed by a nuclear explosion interfere with the laboratory experiments being carried on by the world's scientists.

Just detecting the fact that some nation has detonated a bomb is fairly easy and can be accomplished with the tools of the uranium prospector, Geiger and scintillation counters. There is a normal radiation count known as background count present in the atmosphere at all times. For the nation's capital, it is between 20 and 30 clicks a minute. When the number of counts or clicks doubles or triples, it is an indication that a large amount of radioactivity has leaked intentionally or accidentally into the air.

Differences as to time and intensity of such "background" readings on the Pacific and Atlantic coasts and eleswhere would point to the place and time of the explosion.

A more direct way of learning about the explosion is to analyze precipitation carrying radioactive particles. This method was used in Helena, Mont., when the Holter Research Foundation found that the snow contained radioactivity decay presumed to be from the recent Soviet bomb detonation.

Another method of monitoring in wide use is to suck in air through a filter paper. The paper is then analyzed for radioactive particles. From this analysis, scientists can determine what the nuclear device was made of and its approximate size.

At present, a network of 40 observing stations extends across the United States operated jointly by the Atomic Energy Commission and the U.S. Weather Bureau. These together with nine or ten cooperating Canadian stations are constantly monitoring for radio-active fallout.

To pin point exactly where a bomb has been set off pressure-sensing devices can also be used. A detonation will set up a blast wave, which can be picked up by highly sensitive pressure-measuring devices. If three or more devices in different locations record

the blast wave, scientists can then zero in on the exact location of the blast.

Anyone, however, can become his own atomic bomb monitor man by taking daily recordings with a Geiger counter and watching for an increase in the "background" count, or by setting up a pump to pull air through a filter, and then checking the filter paper with a counter.

Effects of Nuclear Tests

➤ THERE ARE risks to life and property involved in continuing to test atomic weapons in the United States, but these risks must be balanced against what is ultimately best for the peoples of the free world.

This is the opinion of Dr. Gordon M. Dunning, a health physicist with the Atomic Energy Commission, in a report on the effects of nuclear weapons testing made to the American Association for the Advancement of Science.

One risk, Dr. Dunning describes, is a possible increase in the number of genetic mutations in the American population. Some scientists, he states, have calculated that about 80,000 mutations may be present among the population living 100 years from now, owing to radiation exposure from all nuclear tests to date.

If this figure is correct, Dr. Dunning explains, then by the same calculations about 120,000,000 additional mutations may be produced by natural causes by the year 2055, assuming no increase in the population over this year's census.

It is generally held, he states, that an increase in mutation rate is undesirable.

Other risks brought on by further testing within the United States, such as internal exposure from radioactivity, have had very little if any adverse effect on life or property up to the present, Dr. Dunning reports.

No one, for example, has been injured by heat radiation outside the Nevada test site. Dr. Dunning also reports that the United States is now enlarging the warning areas both here and at the Pacfic proving ground to prevent danger from fallout in further tests.

The United States uses more water than it does all other materials combined, averaging for each person 1,200 gallons per day, or 1,800 tons a year.

Most shellac is orange when imported, and must be bleached for some applications, such as quality wood finishes, coated playing cards and speciality papers.

Viruses, thought to be the simplest and smallest forms of life, are turning out to be vastly complicated organisms.

Nobel Winner Predicts
Seven New Forms of Matter

News of Nuclear Species

➤ DR. GLENN T. SEABORG, the world's leading element hunter, predicts the creation of seven new forms of matter in the next five to fifteen years.

Dr. Seaborg, Nobel Laureate at the University of California and co-discoverer of plutonium, said elements 102 through 108 are the forms of matter he is talking about.

The most likely method of their production, he said, is in a special kind of atom-smasher now being constructed at Berkeley, Calif., with Atomic Energy Commission funds. This is the "hilac," heavy ion linear accelerator. It will speed up very heavy nuclei, like neon, whose atomic weight is 20.

By stuffing these big nuclei into the nuclei of heavy atoms like uranium, it should be possible to build up the heavier elements. With lighter atomic bullets, the scientists have produced elements up to 101, which was discovered earlier this year.

Dr. Seaborg says elements 102 through 105 should be stable enough to identify chemically. However, elements 106 through 108 probably will decay so rapidly that they can be analyzed only from their radioactivity.

Such elements are important in adding to our knowledge of atomic structure. However, they "live" only a short time before they "die" through radioactive decay, and they can be produced only in minute quantity.

Heavy Hydrogen in Space

➤ DEUTERIUM, hydrogen's heavy twin, has been discovered in interstellar space by three Russian astronomers.

They spotted the very sparse substance by the radio waves it broadcasts. Astronomers have long suspected the existence of deuterium, an H-bomb element, in the vast space between the stars.

Although the amount of deuterium in interstellar space is so minute it could have no practical value to humans, its discovery is expected to yield better understanding of the structure of the Milky Way.

Only four years ago astronomers confirmed directly that space between the stars is filled very sparingly with hydrogen gas. The deuterium now discovered is associated with the hydrogen in a ratio of one atom of deuterium for every 400 atoms of hydrogen.

Hydrogen was the first gas

whose invisible presence was detected by the radio waves it emits. Theoretical evidence suggested there would be only one deuterium atom for every 6,000 normal hydrogen atoms.

Since the Russian astronomers, G. G. Getmanzev, K. S. Stankevitch and V. S. Troitsky reported the much higher abundance, other radio astronomers are now trying to tune in on its radiation to confirm their observations.

The Russians found the deuterium as a small absorption dip in the strong radio radiation being emitted by the center of our Milky Way galaxy, a pin-wheeled shape grouping of billions of stars.

The deuterium signaled its presence at a frequency of 327 megacycles per second, which is a wavelength of 91.6 centimeters, or about three feet. Radio waves in the middle of standard AM broadcasts have wavelengths of about 1,000 feet.

The radiation from deuterium suggests that it has a temperature of 300 degrees absolute.

Heavy Nitrogen 99.8% Pure

➤ RARE HEAVY nitrogen, isotope 15, has been produced in 99.8% purity.

This promises to provide a new and simpler way of extracting from atomic breeders the kind of fissionable uranium made from relatively plentiful thorium.

Announced by Columbia University, the new concentration of nitrogen 15 was accomplished by Prof. T. Ivan Taylor and Dr. William Spindel of Columbia's chemistry department, who used two thin parallel glass columns, each 18 feet high, in which the rare isotope is transferred from nitric oxide gas to nitric acid. By multiplying this many times, the concentration of nitrogen 15 was raised from less than 0.4% in nature to more than 99.8%, with commercial costs of less than $500 a pound probable. The highest concentration of N 15 heretofore, 60%, sold for $175,000 per pound.

At present only a small bottle of N 15 exists in the high purity.

The heavy nitrogen would be used in atomic reactors for breeding uranium 233 from thorium, since N 15 absorbs or wastes very few of the neutrons that do the breeding conversion, compared with ordinary nitrogen 14. The thorium in the form of its nitrate is bombarded by neutrons from the core of an atomic furnace. One hitch in the use of the process has arisen because radiation damage causes the evolution of nitrogen gas from the nitrate. This is troublesome to recombine into nitric acid and finally into more thorium nitrate, but it is hoped that this can be overcome.

Breeding atomic fuel from thorium will allow production of more atomic fuel than is avail-

able from uranium alone.

Nitrogen 15 will be used immediately for studies upon the constitution of the nitrogen nucleus. Bombardments with the new AEC-supported 6,000,000 electron volt Van de Graaff accelerator at Columbia will determine energy level in the atoms of the two kinds of nitrogen.

The heavier nitrogen will also find use in studies of photosynthesis and other biological and medical reactions involving nitrogen. The weight 15 variety can be distinguished from the common sort by use of the mass spectrometer. It is not radioactive like carbon 14 and can not be traced that way.

Proton Beam Helps Patients

➤ PROTONS, the cores or hearts of hydrogen atoms, have been used with good results in treating patients with advanced cancer of the breast, Dr. John H. Lawrence, director of the Donner Laboratory of Medical Physics at Berkeley, Calif., announced at a recent meeting of the American Medical Association.

The protons were beamed from the synchrocyclotron, a super atom smasher. This proton beam, unlike X-rays or gamma rays from radium, does not scatter. It remains narrow and can therefore be used for pin-point irradiation of very small targets deep within the body. A further advantage is that its dose becomes four times more powerful within the body than at the surface.

The cancer patients had the proton beam directed at their pituitary glands deep within their heads. The object of the treatment was to depress gland functions that might have been stimulating the spread of cancer.

All 14 patients treated so far showed the hoped-for changes, though they had previously not improved under other kinds of treatment.

Whether or not there will be a practical application of this beam in therapy of cancer or other conditions by this form of selective irradiation cannot be estimated until we have had an opportunity to observe these patients for another two or three years, Dr. Lawrence said.

Special ceramic-base brake lining designed to meet the searing heat of high-speed aircraft brakes is now being manufactured as lining for industrial and automotive clutches.

There is more commercial grade uranium known to exist today than almost anyone believed possible ten years ago.

Nuclear Weapons Tests Hinder Dating of Past

New C14 Method Avoids Background

▸ ATOMIC WEAPONS tests on both sides of the Iron Curtain have forced scientists to adopt new techniques for dating the age of ancient materials by their content of radioactive carbon 14.

In a series of attempts to date materials from carbon 14 content reported in 1953, a group of Yale University scientists found that acceptable results were obtained only when nuclear weapons were not being tested in Nevada or the Pacific. Later, in August, 1954, the Yale laboratory found some test blanks of anthracite coal used in dating were contaminated, presumably as a result of Soviet nuclear explosions.

The Yale scientists then were using the solid-carbon dating system developed by Dr. Willard F. Libby of the University of Chicago and now a U.S. Atomic Energy Commissioner. In this system, carbon in fossil materials to be tested is isolated as solid carbon and checked for radioactivity, which measures its approximate age. Trouble appeared when the increased "radioactive background" in the air due to nuclear explosions became mixed with radiation from the carbon, giving false readings.

In a new series of datings reported by Drs. Richard S. Preston and E. S. Deevey and Mrs. Elaine Person of Yale, the solid-carbon system was abandoned for the "acetylene" system developed by Dr. Hans Suess of the U. S. Geological Survey.

Dr. Suess' method for carbon 14 dating involves changing the carbon into the gas, acetylene, instead of keeping it a solid. This allows the testing to be carried out in a vacuum, thus shielding it from background radiation in the air.

Most of the dates in the new list of fossil materials studied by the Yale laboratory, including all satisfactory figures obtained since February, 1954, were taken by the Suess method, the scientists reported in the journal, Science.

Results from the dating of ancient materials from Canada indicate that the last glacial stage of the Ice Age occurred much closer to the present than many geologists have suspected.

The date of wood found under glacial deposits near St. Pierre-Les-Becquets, Quebec, was set as greater than 30,000 years ago, giving a rough approximation of the start of this glacial period in

the area. Then, dating of buried peat near Dugwal, Ontario, showed that the ice had retreated enough to allow peat moss to grow by 6,730 plus or minus 200 years ago, setting a limit on the glacial stage's duration.

Many experts have thought that the last glacial stage left some 25,000 years ago, instead of the much more recent date the carbon 14 indicates.

The Yale scientists were able to give a close date to the mighty eruption of Mount Mazama that formed Crater Lake, about 7,610 plus or minus 120 years ago. This figure was derived by dating rodent droppings found in Paisley Cave, Ore., buried immediately beneath the pumice layer strewn by the erupting volcano.

New light was thrown on an archeological problem as the carbon 14 dating disclosed charcoal from a Saladero Indian culture site in Venezuela to be about 2,800 years old. This gave an unexpectedly early date for the first appearance of agriculture and pottery in the eastern Caribbean, the scientists said.

Treasury of Pure Chemicals Urged

➤ A WELL-FINANCED program for producing pure samples of a selected list of rare hydrocarbon chemicals, including fluorocarbons, was advocated by Dr. Joel H. Hildebrand, president of the American Chemical Society, as a national resource.

Preparation of these compounds for use in handling uranium for atomic bomb development during the last war proved a difficult and expensive undertaking. Ability to draw on a treasury of chemicals kept in preparation for the sake of their theoretical usefulness would be a boon to chemists faced with similar emergency problems in the future, Dr. Hildebrand urged.

Great varieties of new products will extend the list of slow burning organic materials useful at high temperatures, it was revealed at special American Chemical Society sessions devoted to new fluorine compounds.

Skill in using the spectacular element fluorine, which burns readily but forms fireproof compounds, has increased since the war.

Chemists familiar with the development of new materials resulting from this progress described oils and waxes, organic acids and materials which promote mixing of dissimilar liquids, all containing fluorine, many with the addition of chlorine. Silicones also can be combined with fluorine-containing substances, to combine the useful qualities of both series of new materials.

Demands For Water Worry U.S. Experts

Our Diminishing Water Supply

▸ A SERIES of sudden blows to the nation's water supply since 1940 has sent experts scurrying out for ways to conserve this diminishing vital resource as well as open up new water supplies.

According to Karl O. Kohler Jr., director of the U.S. Soil Conservation Service's engineering division, the great demands of World War II, unexpected increases in population, shifts in industry, droughts and pollution of streams and lakes have accelerated the need for water while decreasing the ready supply.

The U.S. population has grown far above normal expectations, he said. In 1940, the projected population for 1975 was 175,000,000 people. Since then, the estimate has had to be revised upward to 200,000,000. Mr. Kohler said water used for human consumption over the U.S. averages 137 gallons a person a day.

The growing number of people means a growing demand for more agricultural land. It takes an estimated 2.5 acres of cropland to support each individual in the United States. To find this new acreage, more land is being put under irrigation.

And the greatest single use of fresh water in the U.S. is for irrigation, 75 to 100 billion gallons a day, or about one half of the fresh water used here annually.

Next largest water consumer is industry, especially steam powerplants, Mr. Kohler said, using about 70 billion gallons of fresh water daily in addition to brackish and salt water used in cooling. A large paper mill uses more water each day than does a city of 50,000 inhabitants, he said.

The rapid industrial expansion since 1938, along with reduced stream flow in drought areas, has increased the growing problem of pollution of streams and rivers, he said. Seriousness of the pollution problem is becoming more apparent as it discourages industrial expansion in some areas, while threatening numerous municipal water supplies.

A large increase in use of water already available can be made through conservation and reuse. According to Mr. Kohler, present supplies can be extended through:

1. Adoption of laws for controlling the conservation and distribution of surface and groundwater resources for beneficial use.

2. Planning on a river-basin basis for natural resource de-

velopment where all interrelated water users are included.

3. Reclamation of what today is called waste water.

4. More efficient use of industrial waters.

5. Better land-use practices to control natural precipitation and reduce movement of sediment.

6. More efficient handling of irrigation water to reduce transportation loss and increase efficiency of application.

7. Reduction of evaporation from water surfaces.

New sources of water being investigated and, to a degree, utilized, include:

1. Reduction of losses through elimination of unwanted, water-consuming plants.

2. More economical manufacture of fresh water from sea water.

3. "Cloud seeding" for the inducement or control of precipitation.

4. Additional development of underground and surface water.

Mr. Kohler said that as shortages appear, less economical water supplies will have to be developed at great cost per unit of water.

He made his report on U.S. water supply problems in the U.S. Department of Agriculture yearbook for 1955, "Water."

Odd Poisoning Symptoms

➤ PATIENTS poisoned by carbon disulfide, used in making rayon or artificial silk, may appear to have stomach ulcers, mental depression, chronic alcholism, lead poisoning, brain tumor or multiple sclerosis, two New York doctors reported in the Journal of the American Medical Association.

They described a case with stomach ulcers and another with mental depression.

Some symptoms include headache, weakness, nausea, inability to concentrate, forgetfulness, unsteadiness, double vision, impotency, temper outbursts, numbness of the hands, and anemia.

Present standards of safety based on the air concentration of carbon disulfide vapor are now too low and should be raised by the American Standards Association, the physicians declared. Poisonings could be prevented by adequate ventilation of rooms where the chemical is used.

Early diagnosis also is essential, because many advanced cases of carbon disulfide poisoning do not respond to treatment. Some of the symptoms in the two reported cases had appeared 10 years before their cause was recognized.

The report was from Drs. Irving R. Tabershaw and Morris Kleinfeld of the New York Department of Labor.

Synthetic Training Urged As Space Flight Prelude

Conditions For Space Flight

➤ THE FIRST space ship zooming into the uncharted interplanetary dark will be manned by humans who have learned their jobs and met all foreseeable emergencies in a ground-based synthetic trainer.

The earthbound device will be much more complex than any now used for training jet pilots, G. Vincent Amico of the Special Devices Center, Sands Point, N. Y., states. The Special Devices Center, run by the Office of Naval Research, has long been a leader in developing synthetic training equipment.

Crew quarters, Mr. Amico says, are very important in duplicating the environment that would be encountered during space flight. Demands for comfort would far exceed any now built into crew compartments, since time spent in the ship would be so much longer than in present-day flights.

The space flight trainer would have to duplicate faithfully both successful flight performance and emergency conditions. Complex computing and control equipment, possibly rivaling those in a space ship itself, would be needed to transmit information from the trainer to the crew and the instructor.

Peculiar to space flight, Mr. Amico points out, are the problems of exceedingly fast take-off, changes in the ship's mass, gravity variations, and recording and predicting the ship's path.

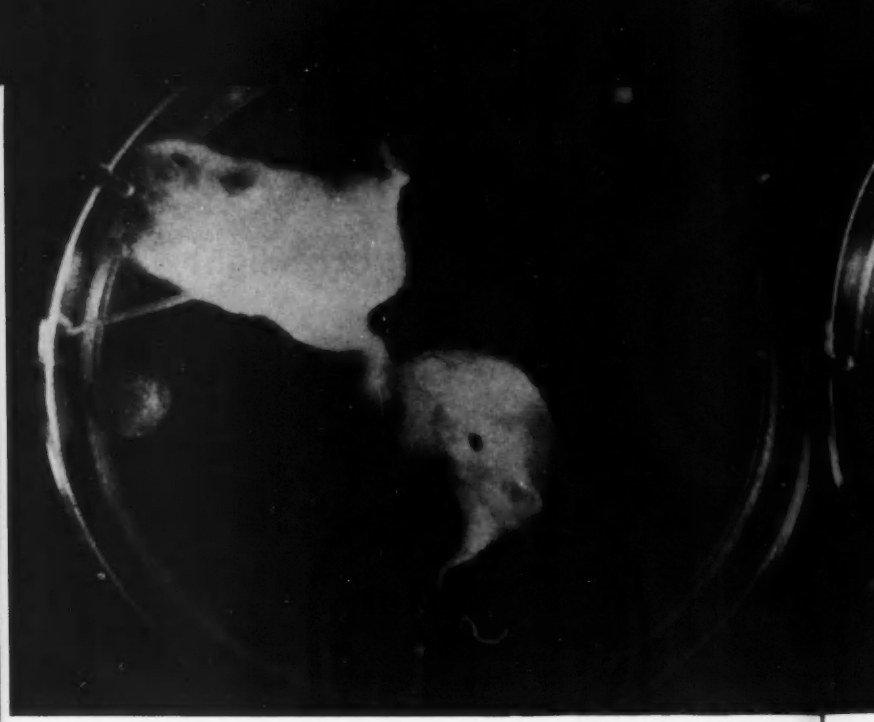
The instructor's station would be the simulator's nerve center. Television cameras would allow constant observation of each man's actions and conduct as he did his job and reacted to imposed conditions. The instructor might generate uncomfortable temperatures, dangerous pressures or excessive radiation to indicate possible difficulties of actual operations.

Those who participate in space flight some time in the future will need a supreme confidence that could be gained only by repeated experience with conditions approximating as nearly as possible the most challenging of earthman's frontier, that of space beyond the earth's atmosphere, Mr. Amico concludes.

No One Should Own Outer Space

➤ WHO OWNS outer space?

No one owns outer space. No one should own outer space. These are the answers of Andrew G. Haley, director and general counsel of the American Rocket



— Photograph by U. S. Air Force

➤ WEIGHTLESS *mice float about without too much apparent discomfort in a test flight, in an Air Force rocket which reached a height where gravity had little pull. The test was made to forecast the probable reactions of men in future space flights.*

Society, who is writing a book on space law.

Outer space, Mr. Haley believes, may be claimed by man only "for the benefit of all mankind and to the detriment of no other intelligent creature."

All humanity is directly involved in solving the problem of ownership of regions beyond the "aeropause," defined as the altitude at which the atmosphere ends and space begins.

Many people believe the United Nations should lay claim to outer space. Mr. Haley agrees that, for the present, UN organizations are the only ones available to handle the problem. But he warns that in the long run, outer space can not belong to anyone.

Meanwhile, he recommends, the UN should set up a commission to study the problem's legal aspects, trying particularly to reach an understanding among all nations on the question of jurisdiction. He suggests that UNESCO should collect all scientific

— Photograph by U. S. Air Force

▸ MOTION *pictures taken during the flight of an Air Force rocket in 1952 show that the mouse in these two pictures which had a shelf to hold onto took his flight calmly. The Air Research and Development Command interprets these films to indicate that human pilots will behave as well under similar conditions.*

information on space flight.

Mr. Haley thinks that July 29, 1955, was a momentous day in history, not only because international announcement was made then of United States plans to launch several small unmanned satellites, but because no nation protested the plans.

Under existing international law, Mr. Haley says, any state could have declared that no man-made earth satellite could circle over its territory, and that violating the territory, even 200 miles in space, would be an act of war. Any state could have insisted that international agreement preceed planning the launching, or that the very planning would require international sanctions.

Quite to the contrary, Mr. Haley points out in his report to the American Rocket Society on space law, none complained, none protested and the program is proceeding. The scientists have benefited mankind as a whole in a

field where the lawyers might well have failed.

Space law will have to be based on natural law, defined by Aristotle as "that which has the same authority everywhere and is independent of opinion."

Planes For A Few Hours

➤ AIRCRAFT of the future may have to be designed to last for only a few hours, and then be scrapped, a research aeronautical engineer reports.

Outlining the problems created by the "thermal barrier," Dr. George Gerard, assistant director of research at the New York University College of Engineering, issued his prediction in Ordnance, official publication of the American Ordnance Association.

It may no longer be possible, Dr. Gerard said, to design a structure for decades of useful life, hours may be a more realistic measure of endurance.

Dr. Gerard forsees two problems that must be mastered before man's missiles can break through the earth's atmosphere at supersonic speed: heat and the softening of materials under increased stress, known as creep.

At five times the speed of sound at sea level (approximately 3,750 miles per hour), temperatures are encountered that are sufficient to melt the best aluminium alloys now known, he points out. This, coupled with a weight penalty, due to weakening of materials brought on by aerodynamic heating, may limit sustained flight to the region below 800 degrees Fahrenheit, or three and one-half times the speed of sound. (Speed of sound is approximately 750 miles per hour at sea level).

Dr. Gerard explains that there are several distinct possibilities for conquering the problems of sustained "thermal" flight. Chiefly, he explains, they offer means of "skirting" the thermal barrier.

One solution in the foreseeable future will be the incorporation of nuclear power plants in aircraft to solve the fuel problem. This, he reports, may give scientists and engineers a steady-state temperature.

The research engineer listed several different views now held by scientists for beating the heat problem, such as using various types of systems to cool the aircraft; flying faster than twice the speed of sound for only a short time; using insulation to delay heating effects; or designing craft to carry loads at elevated temperatures.

Breaking through the thermal barrier, Dr. Gerard concludes, will not be a quick easy accomplishment. The new design philosophy, that Dr. Gerard foresees as necessary for supersonic sustained flight, must account for the creep of metals at high temperatures.

Conditions in the Atmosphere Could be Observed From Above

Satellite For Storm Patrol

▸ HURRICANES could easily be spotted from an earth satellite zooming around the world some 200 miles above the surface.

The satellite could be unmanned—a television camera could beam the scene to weathermen below.

Getting such a bird's eye view of the earth's weather would be of "extreme value," it is stated by Dr. Harry Wexler, the U. S. Weather Bureau's director of meteorological research.

It would be impossible to keep track of the violent tropical disturbances from one man-made moonlet for more than two or three hours out of twenty-four.

Two or three satellites, however, might be timed to take fixes on the giant storm's position every three or four hours, depending on their altitudes and direction of circling, Dr. Wexler pointed out.

Another method of spotting and tracking hurricanes, Dr. Wexler said, would be to send up a large number of rockets over the area. These would go almost as high as the satellite. Although rockets remain aloft only a very short time, a few seconds are sufficient to get the required pictures of the weather over a limited area.

Storms whose presence is only suspected by earthbound meteorologists, Dr. Wexler pointed out, can be definitely identified and located from rockets.

This was the case in the storm of Oct. 5-6, 1954, that produced severe flooding over Del Rio, Tex., which was photographed by a Naval Research Laboratory rocket on Oct. 5. Not until much later did Dr. L. F. Hubert, also of the Weather Bureau, and Dr. Otto Berg of the Naval Research Laboratory, discover the early spotting of the incipient cloudburst on a rocket-taken photograph.

If the rocket had been equipped to televise such information back to meteorologists, Dr. Wexler said, the storm could have been spotted immediately.

From an earth-circling satellite, a hurricane would appear as a tiny pinwheel of clouds, Dr. Wexler said. Other cloud formations could also be seen.

From later studies of clouds' positions and of the path taken by the hurricane, weathermen might soon learn how to predict where hurricanes are headed while they are still in their formative stages.

Earth Satellite Makes Space the Slave of Man

Jobs For Earth's Satellite

➤ EARTH's first artificial satellite, along with artificial nuclear fission, are the "greatest achievements of man's conquest over nature," says Dr. Fred L. Whipple, director of the Smithsonian Astrophysical Observatory.

Space will now become the slave of man, as matter and energy are already, he predicts. Just what can be learned from the continued observations from above the earth's atmosphere cannot be foreseen.

Both professional and amateur astronomers, Dr. Whipple told members of the American Astronomical Society will be able to make direct observations of the satellite.

The man-made satellite will probably be launched from within the United States, and will pass over many already established observatories. Nevertheless, the object will be moving so fast, it will be difficult to photograph precisely.

Dr. Whipple calculates the satellite will be near the limit of naked eye visibility, but easily observable under ideal circumstances with binoculars.

Special devices may be needed for following its motion, since it will be moving about one degree every second. Time determinations will also have to be exceedingly accurate.

The first problem to be solved with the satellite is to find the density of the earth's high atmosphere by measuring the changes in the object's orbit due to resistance. Reasonably good observations, Dr. Whipple pointed out, would give very precise results, much better than those made from rockets.

Geometrical observations of the satellite will yield extremely good determination of the earth's shape, including positions known to within ten feet.

Measurements likely to be made from the satellite, Dr. Whipple said, would include those of cosmic rays and high energy particles; solar radiation; micrometeors; the earth's magnetic field, and hydrogen in interstellar space.

May Circle Many Weeks

➤ AT LEAST one of the ten instrumented satellites to be launched during the International Geophysical Year should circle the earth for many weeks, Dr. Joseph Kaplan of the University of California has predicted.

– Photograph by U. S. Navy

▸ EARTH *as the rocket saw it, gives a preview of how our planet would appear from the artificial satellite, planned for launching during the coming Geophysical Year. Note the appearance of the hurricane.*

He told the American Astronomical Society meeting that a satellite would circle the earth this long if satisfactory orbits are achieved.

The satellites will travel at about 18,000 miles per hour, girdling the earth approximately every hour and a half. Their nearest point to earth will be 800 or 900 miles. The difference is because the orbit at first will be elliptical, not circular.

As chairman of the U. S. National Committee for the International Geophysical Year, during which the satellite will be launched, Dr. Kaplan revealed for the first time to the astronomers the nine members of the Technical Panel on the Earth Satellite Program.

The panel, Dr. Kaplan said, will be responsible for developing, coordinating and directing the over-all scientific satellite effort.

Its chairman is Dr. R. W. Porter, a consultant on communications and control equipment to General Electric Company.

Besides Dr. Kaplan, the members include Hugh Odishaw, executive secretary of the U. S. geophysical year committee; Dr. Homer E. Newell of the Naval Research Laboratory; Dr. W. H. Pickering, director of the Univer-

sity of California's Jet Propulsion Laboratory; Dr. A. F. Spilhaus, dean of the University of Minnesota's Institute of Technology; Dr. Lyman Spitzer, Princeton University astronomy professor; Dr. J. A. Van Allen of the University of Iowa, and Dr. F. L. Whipple, director of the Smithsonian Astrophysical Observatory.

In outlining the astronomical observations to be made during the International Geophysical Year, Dr. Kaplan said that, although rockets had briefly pierced the "ion curtain," the satellite program would make a permanent breach. Ion curtain is short for the ionosphere, a thin region of rarefied gas high in the atmosphere, in which are found free positive and negative ions split apart by the sun's ultraviolet energy.

Help Space Ship Design

➤ RESEARCH with earth's first man-made satellites will help future designers of space stations and space ships, the scientist in charge of U. S. participation in the International Geophysical Year said.

Cosmic ray measurements and counts of small meteoric particles to be made from the satellites will be of particular interest from a practical point of view, Dr. Joseph Kaplan told the American Rocket Society meeting.

Cosmic rays interest the promoter of space travel, the University of California physicist said, because they are a possible hazard to man. Their effects on humans above the earth's protecting atmosphere are unknown. Their origin is also unknown, but is thought to be linked fundamentally to the structure of the universe.

Tiny meteoric particles too small to be seen as "shooting stars" rain on the earth, possibly as many as 1,000 tons per day sifting to the surface, Dr. Kaplan said. These might pit and eventually destroy man-made vehicles in space, so are of concern to space station designers.

Dr. Kaplan outlined the types of experiments for which the Year in 1957-58 will be used.

Included in his list of seven was the first direct determination of the density of hydrogen atoms and ions in interplanetary space, which is not a complete vacuum. Scientists estimate there is one hydrogen atom occupying about each three cubic inches of space on the average.

Dr. Herbert Friedman and his co-workers at the Naval Research Laboratory in Washington suggested the satellite be equipped to measure the sun's hydrogen radiation in the part of its spectrum known as Lyman alpha. At the same time, the hydrogen radiation in this range would be be measured from another direction.

Comparison of the two would give the measure of the amount of hydrogen in interstellar space.

Other experiments outlined by Dr. Kaplan are:

1. Determination of the outer atmosphere's density at various heights by observing how the satellites' orbits change due to air drag.

2. Obtaining more accurate measurements of the earth's diameter at the equator and of intercontinental distances.

3. Observing changes in the sun's ultraviolet radiation over long periods of time.

4. Studies of intensities and variations in cosmic rays and other radiation impinging on the atmosphere.

5. Determining the mass distribution in the earth's crust along the points over which the satellite passes.

6. Observing the giant ring of invisible electricity circling the earth, known as the Stormer current ring.

On the Back Cover

➤ ZOOMING *into space goes a rocket exploring the airless place beyond the atmosphere of our globe. Some of the conditions to be met there and the questions to be answered are told in this issue of* CHEMISTRY. *Official U. S. Navy photograph.*

Tiny Battery Good For Two Years

➤ A NEW button-sized battery that can deliver electricity at constant voltage continuously for two years has been developed.

The "micro-cell" was designed by the Elgin National Watch Company to power an electronic wrist watch now under development, but the battery could also run such devices as a photoflash unit, a hearing aid, a miniature dictating machine or a portable radio.

Use of the element indium, a soft and silvery metal, as the anode of the battery eliminates gassing and leakage that normally plagues other miniature cells.

The new battery, a half circle that occupies the volume of a penny, has 25% more capacity than any other comparable sealed cell yet developed, the manufacturer claims. It delivers a constant voltage of 1.15 for two years with reliability.

For the Home Lab

Sucrose

by Burton L. Hawk

➤ There exists a large group of carbohydrates, most of which have a sweet taste, which are called *sugars*. The group is further divided into the simple sugars or *monosaccharides* with the general formula $C_6H_{12}O_6$ and the *disaccharides* with the formula $C_{12}H_{22}O_{11}$. By far the most common sugar is sucrose, or common cane sugar, which is a disaccharide.

You will be amazed to know that cane sugar is obtained from the sugar cane. The juices from the plants are evaporated and the sugar crystallized. The viscous liquid remaining is known as *molasses* and consists of a mixture of sugars and mineral matter. Perhaps you have heard of it.

Physical Properties

Ordinary sugar from the grocery store is available in the granular or powdered form. We used to purchase the latter as "4-X" sugar, but have now been informed that it is a new improved variety known as *10-X*. Such is the progress of science! Sugar also forms large monoclinic crystals known as "rock candy". To prepare the candy, fill a tall narrow beaker half full of water. Bring to a boil and sift sugar into the boiling liquid until no more dissolves. You will find that sugar is very soluable in water and a considerable amount must be added before the saturation point is reached. Discontinue heating and suspend a string in the solution. Tie a weight (such as a bolt or nut) on one end of the string and lower it gently into the solution almost to the bottom but not touching the glass. Tie the other end of the string to a bar or clamp attached to a ring stand and suspended a few inches above the beaker. Allow the entire apparatus to stand quietly for some time. The rock candy will crystallize and adhere to the string.

Sugar will burn as you can demonstrate by igniting a lump with a match. Or you can heat a spoonful of the granulated form over a flame until it bursts into flame itself.

Sugar even glows in the dark! This is an old trick; perhaps you are familiar with it. Simply rub two lumps of sugar vigorously together in a dark room. Look carefully for little flashes of light.

When sucrose is heated gently, a brown, sticky, pleasant-smelling substance known as *caramel* is obtained. Place a teaspoonful of

sugar in a dry watch glass or evaporating dish. Apply gentle heat with constant stirring. It will melt at first and gradually turn yellow, then brown. This brown caramel is widely used as a coloring agent in beverages. Dissolve a small quantity of it in water and note its coloring ability.

Of course, if sugar is heated too rapidly it will char. Sulfuric acid, acting as a dehydrating agent, will also cause sugar to char. Place two grams of sucrose in a test tube and add 2 cc. of water. Stir and then add 3 or 4 cc. of concentrated sulfuric acid. Stir again. Note the solution immediately turns black and the odor of burning sugar can be detected. A more dramatic way of demonstrating this is by adding the concentrated sulfuric acid to a teaspoonful of dry sucrose in a large evaporating dish. The mixture turns yellow and rapidly darkens. Apply very gentle heat. The charred sugar puffs up, gases are expelled, and a voluminous mass of carbon remains.

Hydrolysis

Sucrose, a disaccharide, can be hydrolyzed to form monosaccharides, glucose and fructose:

$$\underset{\textit{sucrose}}{C_{12}H_{22}O_{11}} + H_2O \rightarrow \underset{\textit{glucose}}{C_6H_{12}O_6} + \underset{\textit{fructose}}{C_6H_{12}O_6}$$

The mixture of glucose and fructose thus formed is called *invert sugar*. Sucrose will not reduce Fehling's or Benedict's solution; but an invert sugar will. Dissolve 2 grams of sucrose in 20 cc. of water. Add Fehling's or Benedict's solution (see below) to a small portion of this solution. There is no reaction. Now pour another portion (about 10 cc.) of the sugar solution into a test tube and add about 20 drops of concentrated hydrochloric acid and heat gently, but do not boil, for about 5 minutes. Allow to cool and then exactly neutralize the solution with dilute sodium hydroxide. A good way to do this is to add a few drops of phenolphthalein solution to the sugar solution. Add the sodium hydroxide solution, drop by drop, until a *faint pink* color develops and does not disappear on shaking. Now add Fehling's or Benedict's solution and heat to boiling. A reddish precipitate is obtained (cuprous oxide). The test solution has been reduced indicating the presence of an invert sugar.

An invert sugar can also be obtained by enzymatic hydrolysis. Break up about $\frac{1}{8}$ of an ordinary yeast cake into a mortar. Add water, a little at a time, and grind with a pestle until a smooth suspension is formed. Add a little more water followed by an equal amount of sucrose solution. Transfer to a test tube, stir, and immerse the tube in a container of hot water and allow to stand there for fifteen minutes. Remove

and add the test solution to a portion of the yeast-sugar mixture. Heat to boiling. Note the reddish precipitate is formed indicating that the yeast has caused the hydrolysis of sucrose to an invert sugar.

Molisch's Test

A test for the presence of sugar or carbohydrates can be performed with Molisch's reagent (see below). Add a few drops of the reagent to about 5 cc. of dilute sucrose solution. In another test tube place 5 cc. of concentrated sulfuric acid. Tilt this tube and cautiously pour the sugar solution down the inside of the tube so that it will float on the surface of the acid without mixing. Note the color formation at the junction of the two liquids.

Oxidation

When sugar is oxidized with nitric acid, the poisonous oxalic acid is obtained. Place 5 grams of sucrose in a large flask. Add 25 cc. of concentrated nitric acid and heat gently. Soon, as the sugar dissolves, a vigorous reaction takes place accompanied by the evolution of large quantities of brown nitrous fumes. At this point remove the flask from the flame and place in a well-ventilated spot until the action subsides. Do not inhale the fumes as they are poisonous. After all action has ceased, evaporate the liquid until it is reduced to about 10 cc. Set the dish aside in a warm place for a day or two, when oxalic acid crystals will form.

Test Reagents

Fehling's Solution. Fehling's test reagent consists of two solutions which are kept separate until ready for use. They are then mixed in equal volume and added to the solution to be tested.

Solution No. 1 — Dissolve 1.5 grams of copper sulfate in 50 cc. of water.

Solution No. 2 — Dissolve 8.5 grams of Rochelle salt (sodium potassium tartrate) in 10 cc. of warm water. Add a solution of 2.5 grams sodium hydroxide in 10 cc. of water. Finally, dilute the mixture with 30 cc. of water.

Benedict's Solution. Benedict's solution is a modification of Fehling's. Only one solution is required. Dissolve 10 grams of sodium citrate and 6 grams of anhydrous sodium carbonate in 50 cc. of hot water. Add slowly, stirring constantly, a solution of 1 gram copper sulfate in 10 cc. of water. Filter the resultant solution.

Molisch's Solution. Dissolve 5 grams of a-naphthol in 50 cc. of ethyl alcohol.

In a modern coke oven, one ton of coal yields eight gallons of tar, 20 pounds of ammonium sulfate, 10,000 cubic feet of surplus gas and about three gallons of light oils.

Silicones, Borates, Titanates, Important Chemical Families

Test-Tube Families

Reprinted from the INDUSTRIAL BULLETIN of Arthur D. Little, Inc.

➤ MANY new chemical products owe their introduction to a thorough exploration of the chemical families to which they belong. Frequently, related compounds will show similar behavior in projected applications, or progressive changes in chemical and physical properties may be obtained from neighboring members of a series. A number of these chemical families — for example, the silicones, titanates, borates, and the group called chelates — are already in commercial use, and wider ranges of application are expected as the families grow in size.

The silicones, introduced 12 years ago, have found wide scope as more silicone compounds have been introduced. Silicones include a skeleton of alternate silicon and oxygen atoms with carbon-containing groups attached to the silicon. Since the structure can be made either chainlike or crosslinked into a network, and can include a variety of attached groups, the products have a wide variety of physical properties, and range from free-flowing liquids through stretchy rubbers to rigid plastics.

The unique properties of silicones result from the unusually stable silicon-oxygen-silicon bond. Molecules of the chain type assume a coiled shape; the gradual opening of the coils with increasing temperature is presumed to be responsible for the wide range of usefulness of silicone liquids. Some, for example, have an unusual ability to adhere to many surfaces; others are used as "nonsticking" agents. One type, available in a wide viscosity range, may be used as a damping fluid for delicate instruments; as a fire-resistant hydraulic fluid; or as a "liquid spring," much smaller for carrying a given load than conventional metal springs. This application is possible because some silicone fluids are highly compressible. Silicone greases prepared by thickening silicone fluids with heat-stable metallic soaps or inert fillers retain their useful properties from — 100° F. to 350° F.; a new fluid silicone lubricant will withstand 500°F.

Several types of resinous silicone electrical insulating materials stand up well to oxidation, moisture, and heat. Electrical equipment may be rewound with silicone insulation to withstand higher overloads or to operate at increased ratings. Protective finishes that withstand long ex-

posure at 500°F. and intermittent exposures up to 1000°F. are used for coating stacks, exhausts, and mufflers, industrial equipment, and domestic appliances. Two new ready-to-mix silicone resins make rigid light plastic foams that resist temperatures up to 700°F. without distortion.

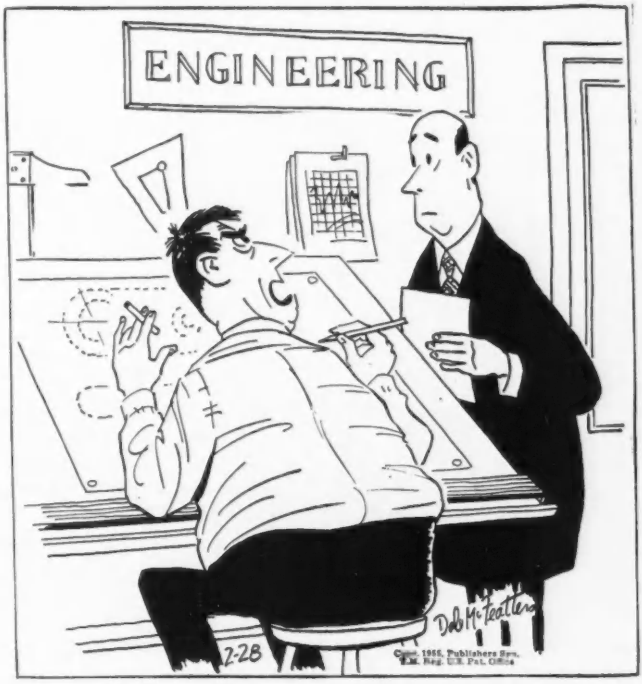
Silicone water repellents include a textile finish for suitings, raincoats, and upholstery that withstands repeated dry cleaning and a protective coating for masonry and asbestos-cement shingles. Silicone plastics do not decompose on aging or exposure to high temperatures, are flexible at low temperatures, chemically inert, and resistant to weather. Silicone rubbers will withstand temperatures up to 600°F., but remain flexible at–120°F. Such rubbers would be especially useful in aircraft ignition cable, for example, where extremes of temperature are encountered at different altitudes.

The element boron is the head of another chemical family. Boron itself is a powerful deoxidizer, has a great affinity for various gases, and absorbs neutrons. Not to be outdone by their parent element, new organic borate esters have already found promising uses. Several firms are now making them in experimental quantities. The cost, from 80 cents to $5 a pound, limits commercial application at present to uses in chemical synthesis. Development of new methods of manufacture, however, should reduce costs and permit use as plasticizers, special solvents, catalysts, paint adhesion promoters, ingredients for soldering and brazing fluxes, and extinguishers for magnesium and other metal fires. Most of the borate esters now available are readily decomposed by water into boric acid and an alcohol – a disadvantage except when it is desired to deposit thin layers of boric acid or boric oxide – but research on the factors influencing sensitivity to water has led to laboratory production of organic borate esters resistant to water. This promises interesting new chemicals based on boron.

Another family, based on titanium, has three branches – titanium esters, chelates, and acylates. An important use for titanium esters was discovered accidentally while they were being tested as possible releasing agents for a metal cavity mold. Instead of opening more easily, the mold would not open at all. Titanium esters were re-examined in the light of this strange behavior and were found to act as effective adhesion promoters, i.e., they form a sandwich film capable of improving the bonding of two surfaces that normally adhere poorly. When titanium esters deposited from dilute organic solutions are allowed to react with moisture in the air or are baked in an oven,

they stick to any substance containing a few reactive groups. They make excellent undercoats for baked and air-dried finishes, and improve adherence of alkyd paints, thiokol rubber, and oil-based exterior paints to old gloss paint and such metals as aluminum and galvanized iron; they also improve vinyl coating adhesion to metals and most papers.

The titanium acylates are made from various organic acids; many are effective anti-corrosion agents for steel. Chelated titanium esters, whose structure enables them to capture metal atoms, are less reactive than the simpler titanium esters, but are effective surface-active agents to minimize pigment bleeding from paint, ink, and plastic surfaces.



➤ "DON'T *bother me! I have to design a better product than the one our competitor designed last month to beat the one I designed the month before!*"

Million Dollar Industry
In Less Than Ten Years

Production of Radioisotopes

Part 2.

By A. F. RUPP, *Oak Ridge National Laboratory*

Short Lived Fission Products

▶ THE PRODUCTION of short-lived fission products is closely associated with iodine-131 production. In addition to the xenon-133 removed from dissolver off-gases, already mentioned in the iodine process, the dissolved uranium solution is a ready source of almost all of the other fission products. The uranium solution is transferred to another cell and the uranium is removed by batch extractors with a suitable solvent. Zirconium-95 - niobium-95 is previously removed from the uranium solution before extraction by passing the uranyl nitrate solution slowly through a bed of silica gel. Over 90% of the Zr^{95}-Nb^{95} is taken up, presumably as a radiocolloid, on the surface for the silica gel. The silica gel can then be washed with reagents such as sulfuric and nitric acid to remove most of the contaminating fission products, and the Zr^{95}-Nb^{95} is eluted in 0.5 *M* oxalic acid. This is an example of an almost ideal type of process where a product is selectively adsorbed in relatively pure form. The other fission products are separated into groups of rare earths, alkaline earths, and ruthenium and cesium. The separation into groups can be accomplished by solvent extraction, ion exchange, or by precipitation techniques with added carrier. Two methods have been used for radioisotope work, the principal one being separation by cation exchange, using selective elution with ammonium citrate solution at various pH values. More recently, the rare earths group has been separated from the alkaline earth group by solvent extraction of the rare earths into tributyl phosphate solution. The alkaline earth group is further separated into its constituents of barium-140 and strontium-89 by elution with ammonium citrate on a Dowex-50 cation exchange column. The ion exchange method is practical if one does not have too much radioactivity per unit volume on the ion exchange column. Severe radiation damage results if more than one or two curies of an energetic beta-emitting radioisotope per cubic centi-

meter of ion exchange resin is placed on the column. The rare earths group is also further fractionated by ion exchange, this time the separation being divided into several main groups and then a refractionation of these groups is made to separate them into the individual components. Yttrium is removed first from the rare earth column, followed by neodymium and praseodymium, then cerium, and finally residual strontium and barium contamination, traces of which accompany the first rare earth group separation. Usually it is necessary to put the rare earth groups from this second fractionation on 4-foot-long cation exchange columns approximately one centimeter in diameter, steam-heated to 98° C., in order to give a very efficient fractionation into pure components. The results obtained on such columns indicate that they have as high as 500 theoretical plates for separation of the rare earth components; products of extremely high purity (99.9%) are obtained.

Cobalt-60

The part of the program in which interest has been growing most rapidly during recent years is the production of kilocurie amounts of cobalt-60 and fission products, such as cesium-137, for use as teletherapy sources, radiographic sources, and sources for irradiation of chemicals, biologicals, and agricultural materials. Cobalt is an ideal material to use for production of gamma sources, since Co^{60} is produced by n-gamma reaction by merely irradiating cobalt metal, which fortunately is monoisotopic, containing 100% cobalt-59. The neutron capture cross section is quite high, 34 barns, although the production rates obtained are somewhat lower than one would calculate, because of the shadowing in the nuclear reactor and the local depression of flux when large amounts of cobalt are placed in the reactor. The practical cross-section for large-scale production is about 15-25 barns, depending upon the number of variables. The practical production rate that we find for cobalt-60 in a flux about 3×10^{13} n/cm^2/sec is about 5 curies Co^{60} per gram of cobalt per month.

The cobalt metal is prepared in various sizes, the most popular being small discs 1 cm and 2 cm in diameter by 1 mm or 2 mm thick. These sources may be placed in various configurations to form teletherapy sources or radiographic sources. Various other shapes and sizes used are cylinders ranging from 1 cm in diameter by 1 cm thick to very small pieces $\frac{1}{16}$" in diameter by $\frac{1}{16}$" thick. Canadian workers also use pellets 1 mm in diameter for co-

balt irradiation. Various kinds of needles and wire have also been irradiated for special purposes, such as insertion into radium-type needles for medical use.

Since cobalt metal is subject to corrosion in moist air (and we have observed that corrosion is accelerated by radiation), the surface of the cobalt has been covered by a very thin electroplated coating of gold; more recently nickel has been used. The main purpose of such a coating is to prevent dusting and flaking of the cobalt during handling. Any Co^{60} to be used for radiography or other purposes must be encapsulated within sealed metallic containers. The various sizes and shapes of Co^{60} pieces are assayed in an especially-designed gamma chamber which has been calibrated carefully against cobalt pieces of the same sizes and shapes that were dissolved, aliquotes removed, and assayed by gamma counting against standards in the laboratory in a large argon-filled gamma chamber. Cross-checks were also made against standard radium sources. Using pieces of cobalt of various sizes calibrated for the geometry of each individual size and shape, the wafers or small cylinders can be assayed to $\pm 5\%$. By combining various shapes and sizes of these capsules, kilocurie teletherapy and industrial radiation sources can be reasonably well-calibrated. The small pieces of cobalt rods and wafers can be put into almost any configuration for irradiation that is desired, which is especially useful for making special gamma sources for specimen irradiation.

Methods For Miscellaneous Products

In addition to radioisotopes produced on a fairly large scale, many other radioisotope preparations are made, most often involving the purification of high specific activity reactor-produced materials or certain important cyclotron-produced radioisotopes. Several examples are given below.

Iron-59 with a specific activity up to 10 curies/g is produced by irradiating iron which has been electromagnetically-enriched to 50% Fe^{58}. After irradiation, some traces of impurities are present, notably Co^{60}. Purification is accomplished by extracting the iron as the chloride from 12 *N* HCl into dichlordiethyl ether, a solvent that is remarkable in that its extraction efficiency becomes greater at low concentrations. The iron is back-extracted with dilute acid and extremely pure $Fe^{59}Cl_3$ is obtained in one or two cycles.

Carrier-free Sb^{125} is isolated from irradiated tin by a method typical of many used for radioisotope preparations. The tin is dissolved in 4 N HCl and passed

through a column filled with 30-mesh granular tin metal. The Sb^{125} is deposited in a thin layer on the top of the granulated tin column. The tin-Sb^{125} layer is removed, dissolved in HCl, and the antimony recovered by co-precipitation with CuS, followed by distillation of $SbCl_5$. The $Sn^{113}Cl_2$ is also recovered, the specific activity being changed only an insignificant amount by passage through the bed of tin metal.

Anion exchange resins are quite useful for purification of radioisotopes, although this method must be used at fairly low radiation levels, since anion exchange resins are easily damaged by radiation. Cobalt-58 is formed by (n,p) reaction during irradiations to produce Ni^{63}. The nickel metal is dissolved in 12 N HCl and passed through a column of anion exchange resin (polystyrene-divinyl benzene type); Co^{58} is taken up on the resin and the pure nickel solution passes through; Co^{58} is eluted with water.

Carrier-free Ca^{45} is produced by(n-p) reaction with scandium. A large amount of gamma emitting Sc^{46} is present, making it desirable to use a procedure easily adapted to remote control. The separation method used is chelation and extraction with a solution of 0.5 *M* thenoyltrifluoroacetone (TTA) in benzene. With a pH of 4.0 in the aqueous layer, scandium is chelated and is extracted into the benzene layer. The water layer contains carrier-free Ca^{45}, which may be extracted into TTA-benzene at pH 9 and back-extracted into water for Ca^{45} purification.

These general methods, or combinations of methods, are used for almost all radioisotope preparations. Co-precipitation, adsorption of radio-colloids, distillation, gasification, and chromatographic separations from adsorption media or cation exchange resins are also important methods in radioisotope production work.

Cyclotron-Produced Radioisotopes

The cyclotron can be used in supplementing the supply of available radioisotopes, since the radionuclides produced in the cyclotron offer a wide range of energies and types of activities; they include neutron-deficient positron and alpha emitters.

The ORNL 86-inch cyclotron is an exceptionally good production instrument, having a steady internal proton beam in excess of one milliampere at an energy of 22 Mev and 2 milliamperes at 18 Mev. These high currents are made possible by the use of wide dees, a high-output ion source, and a radio frequency oscillator

with sufficient power to maintain extremely high dee voltage.

Grazing-incidence targets are designed to allow the beam to strike their surface at a very small angle to increase the effective beam area, thus reducing the power density to a manageable level.

During the past two years, some 20 elements have been bombarded for the production of millicurie to curie quantities of radioisotopes. Some typical ones are: 54d Be^{7} by Li^{7}(p, n); 1.87h F^{18} by F^{19}(p,pn); 310d Mn^{54} by Cr^{54}(p,n) from calutron-enriched Cr^{54}; low specific activity Mn^{54} by Mn^{55} (p,pn); 80d Co^{56} by Fe^{56}(p,n); 270d Co57 by Ni^{58}p,pn; p,2n; p,2p); 250d Zn^{65} by Cu^{65}(p,n); 17.5d As^{74} from Ge^{74}(p,n); 78h Ga^{67} by Zn^{66}(p, 2n); and 2.93y Po^{208} by Bi^{209} (p,2n).

These isotopes were chosen for initial investigation because of their suitability for medical, biological, or industrial application.

Long-Lived Fission Products

Cobalt-60 is an extremely good source of radiation, having two gamma rays per disintegration (117 Mev and 1.33 Mev), and it can be obtained in extremely high specific activity (a maximum of 70 curies per gram obtained up to this time). However, the only moderately-long half-life of 5.3 years and the fact that it is not a true by-product of the nuclear reactor suggest that it may eventually become of secondary importance, especially as a source of industrial gamma radiation as compared with fission-product cesium-137. Cesium-137 has a half-life of 33 years, gamma radiation of 0.67 Mev from its short-lived barium-137 daughter, and is a true by-product, being a fission product which occurs in relatively high yield (6%). Therefore, much attention has been devoted to the separation of large quantities of cesium-137 from reactor wastes. Other fission products in the reactor wastes can be separated at the same time if there is a market for these materials. Other long-lived radioisotopes in wastes which are of greatest interest are strontium-90, cerium-144, ruthenium-106, europium-155, promethium-147, and technetium-99.

In 1948 work was started on the development of industrial-type processes for economically removing these important fission products from reactor wastes and fabricating the radioactive material into suitable sources. The processes have been taken through the laboratory and semi-works stages, during which 1000-curie quantities of Cs^{137} and 100-curie quantities of Sr^{90}, Ce^{144}, and Ru^{106} have been produced. A

simplified flowsheet has been prepared for the process which has been developed. Most emphasis has been placed on the cesium separation and purification process, since it was deemed most valuable of all the fission products. During the development period, many types of processes were tried for the separation of cesium. Since cesium has relatively few insoluble compounds, the first methods tried were all based upon isolating cesium by removing all the other elements in the solution by ion exchange or precipitation. However, many of the reactor wastes are contaminated to a very great extent with Group I elements, such as sodium and potassium. Therefore, a more direct means of isolating cesium was necessary. Various precipitants were tried, such as silicotungstic acid, phospho-tungstic acid, ferrocyanides, and other compounds of this type which have been long known and used for analytical purposes. However, most of these were not well-adapted to industrial-type processes and the most promising process appeared to be the one in which advantage is taken of the co-crystallization of the relatively insoluble cesium alum with potassium or ammonium alum. By saturating the solution with the potassium alum (or as now used, ammonium alum), at approximately 80-90°C., and then cooling to bring down a crop of alum crystals, it was found that the cesium was quite selectively co-crystallized with the batch of cystals that was brought down, more than 99% of cesium being removed from the solution. By decanting off the supernatant liquor, another batch of material containing cesium could be put into the crystallizers and the previous crystals redissolved. More ammonium alum was added to saturate the solution at 80°C., and a new crop of crystals grown, this time including all the cesium that has been brought down during the first step plus the newly added cesium. Successive crystallizations of this type are made and the crop of crystals grown after each crystallization becomes progressively richer in cesium. This procedure can be followed until cesium losses in the supernatant liquor become higher than desired. In the semi-works equipment designed for this process, a number of crystallizers are used, some of which handle the supernatant liquor for recrystallization and recovery of small amounts that have been passed into the supernatant liquor; others are used to concentrate the cesium by dissolving the alum crystals in pure water and then growing smaller batches of crystals to get the cesium into progressively smaller volumes of liquid. If enough cesium is accumulated, it is possible to pre-

cipitate pure cesium-ammonium alum. Cesium-137 in this process comes down almost radiochemically pure (>99%) after one crystallization. Only insignificant amounts of cerium and ruthenium-106 superficially contaminate the first batches of crystals. However, some inactive fission products, such as rubidium, accompany the cesium and must be removed by selective, controlled crystallizations near the end of the process; by these successive crystallizations, one can enrich certain fractions in cesium and others in rubidium. At all stages of the process, the various fractions can be recycled to an appropriate previous point in the crystallization cycle and in this way, losses can easily be kept to a minimum.

The crystallization process is also well adapted to removing cesium, either before or after the other fission products are removed from a fission product mixture. However, in most cases it is probably desirable to remove the other constituents, such as alkaline earths, ruthenium, and rare earths, before the cesium is removed.

Because of its complex chemistry, ruthenium-106 has always been one of the most difficult of the fission products to cope with in fission mixtures. The procedure developed for separating ruthenium from fission product waste consists of controlled homogeneous precipitation of iron at a pH of 2.0 by the hydrolysis of urea, or the controlled addition of very small quantities of ammonia gas into the mixture with high-speed agitation, producing a granular precipitate of hydrated iron oxide which co-precipitates over 90% of the ruthenium and technetium in the solution. This fraction is then removed for storage and combining with other similar fractions from succeeding batches passing through the plant.

All second-stage processing is done by combining portions of similar fractions going through the plant until a large enough quantity is accumulated to process in the later steps in the process, thereby giving a more economical operation.

The effluent from the ruthenium-technetium-iron hydoxide precipitation contains cesium, alkaline earths, and rare earths. The next step is to remove the rare earths as the hydoxides by precipitation from a carbonate-free solution, thus allowing the alkaline earths to pass into the filtrate. The rare earth precipitation is made by passing airborne ammonia gas into the solution with high-speed agitation. The rare earth group precipitates quite completely, there being a plentiful supply of inactive neodymium, lanthanum, and other rare earths to carry down all of the cerium, promethi-

um, and europium that are present. It may be well to remark at this point that with procedures of this kind, where one is dealing with large quantities of fission products, classical methods are usually quite satisfactory, since high enough concentrations of the fission products are present for ordinary precipitations. This is in contrast to the early radiochemical work where only minute concentrations of fission products were available.

After removal of the rare earth group as the hydroxides*, the filtrate containing cesium and the alkaline earths is treated with sodium carbonate to precipitate the alkaline earths, mostly inactive barium and radioactive strontium-90. After this precipitation, there remains only cesium in the effluent for removal by the previously-described alum crystallization process.

The constituents of the main groups are further separated and purified in the following manner. The iron-technetium-ruthenium precipitate is dissolved and the technetium is selectively precipitated as the tetraphenyl arsonium (TPA) pertechnetate. The effluent containing iron-ruthenium is re-precipitated as $Fe(OH)_3$ and is dissolved in concentrated sulfuric acid, treated with potassium permanganate and the ruthenium is distilled, as ruthenium tetroxide, into hydrochloric acid or nitric acid containing sufficient quantities of hydrogen peroxide to reduce the ruthenium to the Ru^{+3} state. The ruthenium chloride solution is then used for the preparation of large sources.

Ruthenium is one of the few fission products that can be easily prepared in metallic form as an electroplated metallic source. The ruthenium chloride (or nitrate) solution is treated with red fuming nitric acid and/ or hydrochloric acid, depending upon the starting solution, to produce ruthenium nitrosochloride. Very satisfactory ruthenium electroplating can be done from a bath of ruthenium nitroso-chloride, producing smooth metallic surfaces. Sources have been made by electroplating ruthenium-106 having a specific activity of approximately 40 curies/g onto copper surfaces, in sufficient thickness to indicate that 10,000 curies could probably be plated onto an area of one square foot. Immediately after electroplating the radioactive ruthenium, the plated source is transferred to a wash solution of sulfurous acid and then placed in a ruthenium nitroso-chloride bath, where a flash covering of inactive metallic ruthenium is placed over the active ruthenium. The plate is then rewashed and placed in a silver cyanide electro-

* Or, the hydroxide and carbonate groups may be brought down together for later separation.

plating bath and plated with a thin coating of silver. The plate is finally slipped into an envelope made of thin stainless steel and sealed by welding. The stainless steel envelope has handling projections for placing the source in carriers and inserting it into radiation devices.

The technetium precipitate of phenyl arsonium pertechnetate is further purified by several re-precipitations as the pertechnetate and then as the technetium sulfide, followed by dissolution in ammonia and hydrogen peroxide to produce ammonium pertechnetate solution as a final product.

The rare earth group contains three main constituents, cerium-144, promethium-147, and europium-155. Of these constituents, cerium-144 is present in by far the largest quantity. Since it provides most of the radiation in moderately old fission product mixtures, it is important to separate it from promethium and europium so they can be further purified in lightly-shielded equipment. Several methods are available for removing cerium-144; namely selective extraction from concentrated nitric acid into tributyl phosphate solutions, or a carefully-controlled precipitation of ceric phosphate in acid solution. Cerium may also be separated from the other rare earths as a ceric iodate; however, this process produces a relatively large quantity of the very voluminous ceric iodate precipitate in which large losses of europium-155 occur. Furthermore, the conversion of the iodate to more usable forms of cerium oxide or hydroxide is very difficult because of the large quantity of iodine to be removed. However, by close pH control, cerium can be removed with about 90% efficiency by precipitating as the ceric phosphate. If the cerium is then reduced to the Ce^{+3} state, it can be re-precipitated as the hydroxide and thus separated from phosphate. The next step after dissolving the cerium hydroxide is to re-precipitate cerium as the oxalate, in which form it can be ignited to ceric oxide. Ceric oxide can either be packed by vibration into thin stainless steel tubes which are sealed by welding, or combined with silica and other ceramic ingredients and fused into thin layers on iron plates, which are then encapsulated within thin stainless steel jackets and sealed by welding. Experiments are still in progress to determine the best way to fabricate cerium sources. However, it appears that it will be necessary in any case to fabricate the cerium in fairly thin layers to prevent self-absorption of the radiation, since only a fraction of the Ce^{144} radiation is hard gamma radiation.

The fractions of rare earths containing promethium and europium are purified by taking up on

a steam heated cation exchange column and selectively eluting with ammonium citrate solution, as previously noted. Radioactivity "peaks" are obtained indicating which fractions are rich in europium and promethium; after separation, these fractions are again fractionated on ion exchange columns to produce products of the desired purity. Europium may be further purified by reducing to the Eu^{+2} state by electrolytic reduction or passage through a zinc metal reductor, followed by co-precipitation with barium sulfate, or direct precipitation if the quantity of Eu is large enough. By oxidation of the europium to Eu^{+3}, it can be separated from barium carrier and sulfate. Further purification may be made by reduction with sodium amalgam and re-extraction from the amalgam as the hydroxide, finally precipitating as the oxalate.

End of Series From Atomic Energy Conference

THE ARTICLES given as papers before the "Atoms for Peace" Conference were especially selected for their lucid explanations of many of the newer aspects of matter.

The series includes: "Three Epochs of Energy," by Homi J. Bhabha, leading Indian physicist, President of the International Conference on the Peaceful Uses of Atomic Energy; "Maxium Intake of Radioisotopes," by Karl Z. Morgan, Walter S. Snyder and Mary R. Ford, Oak Ridge National Laboratory; "Electricity From Radiation", by E. G. Linder, P. Rappaport and J. J. Loferski, Radio Corporation of America; "Modes of Radiation Injury", by Austin M. Brues, Argonne National Laboratory; "Radioactive Tracers", by G. Hevesy; "Report on Research Reactors", (3 parts), by L. Kowarski, Commissariat a l'Energie Atomique, Paris, and European Organization for Nuclear Research, Geneva; "Isotopes in Industry", by S. E. Eaton, Arthur D. Little, Inc.; "Production of Uranium Metal", by L. Grainger, United Kingdom Atomic Energy Authority; "Disposal of Radioactive Wastes at Sea", by Charles E. Renn, The Johns Hopkins University; "Acceleration of Charged Particles", (2 parts), by Vladimir I. Veksler, Russian physicist; "Isotopes in Technology", (2 parts), by P. C. Aebersold,* U. S. Atomic Energy Commission; "Cold Sterilization of Foods", by B. E. Proctor and S. A. Goldblith, Massachusetts Institute of Technology; "Production of Radioisotopes", (2 parts), by A. F. Rupp, Oak Ridge National Laboratory.

* Subscribers to CHEMISTRY will note that Dr. Aebersold's by-line was accidentally ommitted from Part 2 of his article, "Isotopes in Technology" on page 14 of the December 1955 issue. They will wish to letter it in on their file copies, just as it appears on Page 16 of the November issue. —Ed.

Important New Processes Patented by Chemists

Nuclear Processes Disclosed

Copies of patents may be ordered from the U.S. Commissioner of Patents, Washington 25, D.C., at twenty-five cents each. Order by number and enclose remittance in coin, money order or Patent Office coupon, but not stamps.

Man-Made Elements Separated

➤ THE ATOMIC Energy Commission was assigned rights to patent No. 2,711,362, granted to Kenneth Street, Jr. of Berkeley, Calif., for his method for separating curium and americium, two man-made elements heavier than uranium, from the rare-earth elements of the lanthanide series, which they closely resemble chemically.

The process, which uses ion exchange materials, can separate curium, element No. 96, from americium, No. 95, as well as from the lanthanide rare earths and from the other man-made elements heavier than uranium.

Handling Sodium

➤ THE RISK involved in handling sodium for transportation or storage appears to have been solved by what is termed an "unexpected discovery" that polyethylene and metallic sodium are mutually inert chemically and non-adhesive.

Heretofore, sodium presented two difficult problems in its handling: it reacts violently with water to produce a dangerous caustic and hydrogen, and it adheres tenaciously to most packaging materials. Now, however, claims Ernest R. Corneil of Stamford Centre, Ontario, Canada, once encased in polyethylene, sodium can be preserved indefinitely without hazard and without worry about adhesion to the package surface. It does not matter, Mr. Corneil states, whether the sodium be a liquid or a solid. He was awarded patent No. 2,712,384 and assigned the rights to E. I. du Pont de Nemours and Company of Wilmington, Del.

Darkroom Silver Saver

➤ SILVER from solutions used in photographic darkrooms to fix prints can now be saved by aluminum. Ralph B. Maddock of Minneapolis, Minn., earned patent No. 2,712,931 for an apparatus that recovers silver from hypo baths, even while the photos are in the soup.

The device employs a strip of aluminum, which Mr. Maddock claims is the first such method for recovering silver with a metal that is higher than silver in the electromotive series. The silver,

which collects in the container housing the aluminum, is filtered off. In this manner, the inventor was able to get 145 grains of silver from five gallons of used hypo. He assigned the patent rights to the Pako Corporation of Minneapolis.

Pioneer Atomic Inventions

➤ THE LATE Dr. Enrico Fermi, Nobel Prize winner in physics, and Dr. Walter H. Zinn, director of the Argonne National Laboratory, received patent No. 2,714,577 for a nuclear reactor that has a cooled shield, a composite rod for use in the active part of the reactor, and a means for introducing foreign bodies into the active portion of the reactor for bombardment by neutrons. At the same time, Dr. Zinn received patent No. 2,714,668 for a simple device that responds to neutrons from the reactor to act as a safety regulator.

Both inventions are an integral part of the celebrated nuclear reactor invented by Drs. Fermi and Leo Szilard which heralded the atomic age.

Patents for the early atomic inventions were applied for in 1945. They were issued ten years later. Rights for the atomic devices were assigned by their inventors to the U. S. Atomic Energy Commission.

Pulp From Hardwood

➤ TWO SYRACUSE University professors have invented a method for producing groundwood pulp from hardwood. Profs. Clarence E. Libby and Frederic W. O'Neil of the New York State College of Forestry were awarded patent No. 2,713,540 for a chemical mechanical process which they claim has never been previously used to make pulp.

In fact, the scientists say, the pulps produced by our process are so distinctive that we have found it desirable to give them their own names. The two wood technologists call the product from their single cycle "chemigroundwood," and the product of their double cycle process "dichemigroundwood." Hardwoods from poplar to beech, birch and maple can be treated by varying the chemo-mechanical process.

The Syracuse researchers assigned their pulping process patent rights to the New York State College of Forestry at Syracuse, N. Y.

Heat-Absorbing Glass

➤ A TRANSPARENT, heat-absorbing glass with a low expansion and a pale bluish green tint for glare reduction has been invented. By combining the advantages of borosilicate and soda-lime-silica heat absorbing glasses, the two general known types of such glass, Wilbur F. Brown, Glenn C. Mook, Joseph J. Jarosi and Curtis W. Davis, Jr., of Toledo, Ohio., were able to produce a glass that has a relatively high resistance to

fracture as a result of thermal shock.

The glass is made from a combination of sand, limestone, soda ash, salt cake, feldspar, salt, borax, ground coal and rouge. It was issued patent No. 2,714,558. The four inventors assigned the patent rights to Libby-Owens-Ford Glass Company of Toledo.

Old Fingerprints Made New

➤ MAN'S BODY chemicals can be his own undoing in a crime-does-not-pay invention that brings out old and invisible fingerprints.

Invented by Svante Oden of Uppsala, Sweden, the fingerprint detecting process is based on Mr. Oden's discovery that proteins and amino acids leave tell-tale concentrations long after the visible print marks are gone. These can be developed with chemicals. Mr. Oden suggests that two indicators can be used to bring out old and extraordinarily weak prints: ninhydrin in acetone for the amino acids and amido black for the proteins.

By developing the object thought to have prints in solutions of the indicator chemicals, the old fingerprints turn up in color. When ninhydrin is used, Mr. Oden reports, the prints appear in colors ranging from carmine to a bluish-violet.

"When amido black is used the finger line pattern will appear as a dark blue color against a brighter blue background. This developing process gives an especially good result if the fingers which have left the print were stained with blood serum." Mr. Oden was awarded patent No. 2,715,571.

Wet Strength Paper

➤ PAPER that is harder to tear than others when it is wet has been invented. Its invention is based on the discovery that the chemical dimethylamine gives good results for wet paper strength when used to modify some resins now being used for this purpose. Heretofore, the inventor, David B. Hatcher of Toledo, Ohio, states, other dialkylamines were not useful for modification of urea-formaldehyde resins.

The use of Mr. Hatcher's new resin also eliminates the need for treating resins at the pulp plant. In the past he claims, other resins could not be used directly as received. Paper treated with the invention does not rip until the tensile force is 4.7 pounds per six-tenths of an inch paper strip, tests showed.

The paper wet strength process received patent No. 2,715,065. The patent rights were assigned by Mr. Hatcher to the Allied Chemical & Dye Corporation of New York.

Book Condensations

DAMMAR AND MASTIC INFRARED ANALYSIS — Robert L. Feller — *Mellon Institute,* 2 p., illus., paper, free upon request direct to publisher, 4400 Fifth Ave., Pittsburgh 18, Pa.

NEW PRACTICAL FORMULARY—Mitchell Freeman — *Chemical Publishing Co.,* 376 p., $7.95. A book of recipes for use in industry, the laboratory and the home.

INDUSTRIAL FERMENTATIONS: Volume II — Leland A. Underkofler and Richard J. Hickey, Eds. *Chemical Publishing Co.,* 578 p., illus., $12.00. A compilation of modern industrial practices covering particularly the manufacture of vitamins, enzymes and the new antibiotics.

A DIRECTORY OF METALLOGRAPHY — R. T. Rolfe—*Chemical Publishing Co.,* 1st American ed., 287 p., $5.75. An encyclopedic treatment of technical terms from abrasion and absolute temperature to zirconium.

MOLECULAR VIBRATIONS: The Theory of Infrared and Raman Vibrational Spectra — E. Bright Wilson, Jr., J. C. Decius and Paul C. Cross—*McGraw-Hill,* 388 p., illus., $8.50. To aid the reader in using mathematical techniques in analyzing experimental data.

ELECTROLYTE SOLUTIONS: The Measurement and Interpretation of Conductance, Chemical Potential Diffusion in Solutions of Simple Electrolytes—R. A. Robinson and R. H. Stokes—*Academic,* 512 p., illus., $9.50. For the practical electrochemist.

SOLUBILIZATION: And Related Phenomena — Mary Evelyn Laing McBain and Eric Hutchinson—*Academic,* 259 p., illus., $7.00. Dealing with the fundamental principles of solubilization.

DYNAMICAL THEORY OF CRYSTAL LATTICES — Max Born and Kun Huang — *Oxford University Press,* 420 p., illus., $8.00. In the preface Nobelist Max Born states that he started "from the most general principles of quantum theory" and derived "the structures and properties of crystals" and that Huang's main contribution was the "extension of the theory of elasticity of lattices to finite strains."

THE CHEMICAL INDUSTRY FACT BOOK — *Manufacturing Chemists' Association.* 2d ed., 148 p., illus., paper, $1.00 Chemistry has emerged during the first half of this century as a major industry.

THE CHEMISTRY OF SYNTHETIC DYES AND PIGMENTS — H. A. Lubs —*Reinhold,* American Chemical Society Monograph Series, 734 p., $18.50. An authoritative reference work covering developments since the discovery of mauve, the first man-made dye.

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